

What is Claimed is:

- [c1] A watermarked image generator that embeds watermarks into an input image to generate a watermarked output image, comprising:
- a watermark data source that inputs watermark data to a watermark embedding device, the watermark embedding device halftoning the input image to generate the output image made of 2x2 binary patterns, the 2x2 binary patterns forming the watermarks embedded in the output image.
- [c2] The watermarked image generator according to claim 1, wherein the watermark embedding device comprises:
- a tri-level error diffusion generator that performs tri-level error diffusion on a reduced resolution version of the input image by halftoning the input image into black, white and 50% gray; and
 - a plurality of halftoning circuits that successively replace each pixel of the halftoned input image with one of a plurality of the 2X2 binary patterns, the one of the plurality of 2x2 binary patterns selected based on at least one bit of the watermark data when a pixel of the halftoned image data is 50% gray.
- [c3] The watermarked image generator according to claim 2, wherein, when a pixel of the halftoned image data is white, the one of the plurality of 2x2 binary patterns forms an all white pattern.
- [c4] The watermarked image generator according to claim 2, wherein, when a pixel of the halftoned image data is black, the one of the plurality of 2x2 binary patterns forms an all black pattern.
- [c5] The watermarked image generator according to claim 2, wherein the watermark data is binary data, and, when a pixel of the halftoned image data is 50% gray, the one of the 2x2 binary patterns forms one of a plurality of polarized patterns, the one of the plurality of polarized patterns is polarized according to the status of the at least one bit of the binary data.
- [c6] The watermarked image generator according to claim 2, wherein the one of the plurality of 2x2 binary patterns is selected based on two bits of the watermark

data when a pixel of the halftoned image is 50% gray.

[c7] The watermarked image generator according to claim 2, wherein the watermark data is binary data, and, when a pixel of the halftoned image data is 50% gray, the one of the 2x2 binary patterns forms one of a plurality of polarized patterns, the one of the plurality of polarized patterns is polarized according to the values of each of the two bits of the binary data.

[c8] The watermarked image generator according to claim 2, wherein the watermark data is segmentation values of each pixel of the halftoned input image, and, when a pixel of the halftoned input image data is 50% gray, the one of the 2x2 binary patterns forms one of a plurality of polarized patterns, the one of the plurality of polarized patterns is polarized according to the segmentation value for that pixel.

[c9] A method of embedding watermarks received from a watermark data source into a continuous tone input image to generate a watermarked halftone output image, comprising:

halftoning the input image to generate the output image made of 2x2 binary patterns, the 2x2 binary patterns forming the watermarks embedded in the output image.

[c10] The method according to claim 9, further comprising:
performing tri-level error diffusion on a reduced resolution version of the input image by halftoning the continuous tone input image into black, white and 50% gray; and
successively replacing each pixel of the halftoned input image with one of a plurality of the 2x2 binary patterns, the one of the plurality of 2x2 binary patterns selected based on at least one bit of the watermark data when a pixel of the halftoned image data is 50% gray.

[c11] The method according to claim 10, wherein successively replacing each pixel of the halftoned input image with one of a plurality of the 2x2 binary patterns comprises replacing each white pixel of the halftoned image data with one of the plurality of 2x2 binary patterns forming an all white pattern.

[c12] The method according to claim 10, wherein successively replacing each pixel of the halftoned input image with one of a plurality of the 2x2 binary patterns comprises replacing each black pixel of the halftoned image data with one of the plurality of 2x2 binary patterns forming an all black pattern.

[c13] The method according to claim 10, wherein:
the watermark data is binary data; and
successively replacing each pixel of the halftoned input image with one of a plurality of the 2x2 binary patterns comprises replacing each 50% gray pixel of the halftoned image data with one of a plurality of polarized 2x2 binary patterns, the one of the plurality of polarized 2x2 binary patterns being polarized according to a value of the at least one bit of the binary data.

[c14] The watermarked image generator according to claim 10, wherein the one of the plurality of 2x2 binary patterns corresponds to two bits of the watermark data when a pixel of the halftoned image is 50% gray.

[c15] The method according to claim 14, wherein:
the watermark data is binary data; and
successively replacing each pixel of the halftoned input image with one of a plurality of the 2x2 binary patterns comprises replacing each 50% gray pixel of the halftoned image data with one of a plurality of polarized 2x2 binary patterns, the one of the plurality of polarized 2x2 binary patterns being polarized according to a value of two bits of the binary data.

[c16] The method according to claim 10, wherein:
the watermark data is segmentation values of each pixel of the halftoned input image; and
successively replacing each pixel of the halftoned input image with one of a plurality of the 2x2 binary patterns comprises replacing each 50% gray pixel of the halftoned image data with one of a plurality of polarized 2x2 binary patterns, the one of the plurality of polarized 2x2 binary patterns being polarized according to a segmentation value.